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[Document Title] Specification

Title of the Invention: Method for Manufacturing Semiconductor Device, and Semiconductor Device

Claims

Claim 1 A method for manufacturing a semiconductor device sealed with silicone rubber, characterized in that a semiconductor device is placed in a mold, and a sealing silicone rubber composition is supplied between the mold and the semiconductor device and compression molded.

Claim 2 The method for manufacturing a semiconductor device according to Claim 1, characterized in that a semiconductor device is placed in a lower mold, a sealing silicone rubber composition is supplied between the upper mold and the lower mold, and then the semiconductor device is squeezed between the upper and lower molds and the sealing silicone rubber composition is compression molded.

Claim 3 The method for manufacturing a semiconductor device according to Claim 1, characterized in that the silicone rubber composition is a type that cures through a hydrosilylation reaction.

Claim 4 The method for manufacturing a semiconductor device according to Claim 1, characterized in that the silicone rubber composition is one that will cure to form a silicone rubber with a complex elastic modulus of 1 GPa or less.

Claim 5 The method for manufacturing a semiconductor device according to Claim 1, characterized in that two or more semiconductor devices are sealed with silicone rubber and then cut into individual semiconductor devices.

Claim 6 The method for manufacturing a semiconductor device according to Claim 1, characterized in that the semiconductor device is one in which a semiconductor chip is electrically connected by a bonding wire on a circuit substrate.

Claim 7 The method for manufacturing a semiconductor device according to Claim 6, characterized in that a silicone rubber composition is supplied to the side of the circuit substrate on which the semiconductor chip is mounted, and the connection between the semiconductor chip and the bonding wire of said chip is sealed with silicone rubber.

Claim 8 The method for manufacturing a semiconductor device according to Claim 1, characterized in that a release film is applied to the inner surface of the mold.

Claim 9 The method for manufacturing a semiconductor device according to Claim 8, characterized in that the release film is held against the inner surface of the mold by air suction.

Claim 10 A semiconductor device manufactured by the method according to any of Claims 1 to 9.

Detailed Description of the Invention

[0001]

Technological Field to Which the Invention Belongs

The present invention relates to a method for manufacturing a semiconductor device sealed with silicone rubber, and to a semiconductor device manufactured by this method.

[0002]

Prior Art

Transfer molding with a metal mold, potting or screen printing with a liquid sealing resin, and the like are performed in order to seal semiconductor devices with a resin. As semiconductor elements have become smaller in recent years, this has created demand for smaller and thinner electronic devices, making it necessary to resin-seal thin packages no more than 500 $\mu$m in thickness.

[0003]

When a thin package is resin-sealed, transfer molding allows the thickness of the sealing resin to be controlled precisely, but problems are that the semiconductor chip may move up and down while the sealing resin flows in, or the bonding wire connected to the semiconductor chip may be deformed by the flow pressure of the sealing resin, which can lead to disconnection, contact, and so forth.

[0004]

Meanwhile, disconnection and contact of the bonding wire are less likely to occur with potting or screen printing with a liquid sealing resin, but problems are that it is difficult to precisely control the thickness of the sealing resin, and voids develop in the sealing resin.

[0005]

To solve these problems, methods have been proposed in which a resin-sealed semiconductor device is manufactured by placing a semiconductor device in a mold, supplying a molding resin between the mold and the semiconductor device, and then compression molding this resin (see Japanese Laid-Open Patent Applications H8-244064, H11-77733, and 2000-277551).

[0006]

Nevertheless, with the methods proposed in Japanese Laid-Open Patent Applications H8-244064, H11-77733, and 2000-277551, the decreased thickness of the semiconductor chip and the circuit substrate that results from smaller semiconductor elements causes considerable warping of the semiconductor chip or circuit substrate, and the semiconductor device is susceptible to breakage, malfunction, or the like as a result of internal stress.

[0007]

[ Patent Publication 1 ] Japanese Laid-Open Patent Application H8-244064

[ Patent Publication 2 ] Japanese Laid-Open Patent Application H11-77733

[ Patent Publication 3 ] Japanese Laid-Open Patent Application 2000-277551

[0008]

Problems Which the Invention is Intended to Solve

The inventors arrived at the present invention as a result of diligent research aimed at solving the above problems.

Specifically, it is an object of the present invention to provide a method for manufacturing a semiconductor device, with which no voids develop in the sealing of the semiconductor device, the thickness of the sealing rubber can be controlled precisely, there is no disconnection or contact of the bonding wire, and there is less warping of the semiconductor chip or circuit substrate, and provides a semiconductor device having these advantages.

[0009]

Means Used to Solve the Above-Mentioned Problems

The method of the present invention for manufacturing a semiconductor device is characterized in that a semiconductor device is placed in a mold, and a sealing silicone rubber composition is supplied between the mold and the semiconductor device and compression molded.

The semiconductor device of the present invention is characterized by being manufactured by the above method.

[0010]

Embodiments of the Invention

First, the method of the present invention for manufacturing a semiconductor device will be described.

With this method, a semiconductor device is placed in a mold, and a sealing silicone rubber composition is supplied between the mold and the semiconductor device and compression molded. This compression molding machine equipped with a mold can be any commonly used compression molding machine, and should be equipped with upper and lower molds for sandwiching the semiconductor device and allowing the sealing silicone rubber composition supplied into the cavity between the mold and the semiconductor device to be compression molded, clamps for applying pressure to these molds, a heater for heating and curing the sealing silicone rubber composition, and so forth. Examples of such compression molding machines are given in Japanese Laid-Open Patent Applications H8-244064, H11-77733, and 2000-277551, but the one described in Japanese Laid-Open Patent Application 2000-277551 is particularly favorable because of its simplicity.

[0011]

Specifically, with the compression molding machine discussed in Japanese Laid-Open Patent Application 2000-277551, a semiconductor device is placed in a lower mold, a sealing silicone rubber composition is supplied between an upper mold and the semiconductor device, and the semiconductor device is held between the upper and lower molds while the sealing silicone rubber composition is compression molded. This compression molding machine has a clamper which is formed in a shape that surrounds the side surfaces in the sealing region of the upper mold, is supported so as to be able to be raised and lowered in the mold opening and closing direction along these side surfaces, and is biased toward the lower mold, with the bottom surface protruding past the

rubber molding surface of the upper mold when the mold is open. If either the upper or lower mold will come directly into contact with the silicone rubber composition, it is preferable for the molding surfaces of these molds to be coated with a fluororesin. In particular, this compression molding machine is equipped with a release film supply mechanism with which a film that will not stick to the mold or the sealing rubber is supplied at a location where it will cover the sealing region of the upper mold. With a compression molding machine such as this, interposing this release film during the sealing of a semiconductor device prevents the sealing rubber from sticking to the molding surface of the mold, allows the sealing region to be more effectively sealed by the release film, and ensures a good seal free from burrs or the like.

[0012]

This compression molding machine is preferably provided with a release film supply mechanism for supplying a film that will not stick to the mold or the sealing rubber, so that the film covers the surface of the lower mold on which the semiconductor device is placed. A release film suction mechanism is provided for holding the release film by air suction to the bottom surface of the clamper, and for holding the release film by air suction against the inner surface of the resin sealing region (constituted by the resin molding surface of the upper mold and the inner surface of the clamper) by drawing air in from the inner bottom surface of the sealing region, which allows sealing to be performed while the release film is securely supported on the mold surface. It is also preferable for a release film suction mechanism to be provided, in which air holes are formed on the bottom surface of the clamper and air holes are formed on the inner surface of the clamper in communication with an air passage formed between the inner surface of the clamper and the side surface of the upper mold, and an air mechanism for creating air suction is provided to these air holes. The upper mold may also be provided with a cavity that forms an independent molding section corresponding to the position on the semiconductor device where the semiconductor chip is mounted. The lower mold may also be provided with a cavity that forms an independent molding section corresponding to the position

on the semiconductor device where the semiconductor chip is mounted. The upper mold may be supported movably in the direction in which the mold opens and closes, and may be biased toward the lower mold. The molding surface of the lower mold may also be provided with an overflow cavity for containing any sealing silicone rubber composition that overflows from the sealing region during the sealing of the semiconductor device, and the clamping surface of the clamper that presses on the semiconductor device may be provided with a gate path communicating between the overflow cavity and the sealing region.

[0013]

When a semiconductor device is placed in the lower mold, a sealing silicone rubber composition is supplied between the upper mold and the semiconductor device, the rubber molding region is covered with a film that will not stick to the mold or the sealing rubber, and the semiconductor device is sealed while being held along with the sealing silicone rubber composition between the upper and lower molds, it is preferable if, in the holding of the semiconductor device, a clamper which is formed in a shape that surrounds the side surfaces in the sealing region of the upper mold, is supported so as to be able to be raised and lowered in the mold opening and closing direction along these side surfaces, and is biased toward the lower mold, with the bottom surface protruding past the rubber molding surface of the upper mold when the mold is open, is pressed against the semiconductor device, so that the area around the sealing region is sealed, the upper and lower molds are gradually moved closer together and the silicone rubber composition is packed into the sealing region, and the upper and lower molds are stopped at the mold closure position and the silicone rubber composition is packed into the sealing region, thereby sealing the semiconductor device.

[0014]

Fig. 1 shows the main components of a compression molding machine that can be used favorably in this method. 20 is a fixed platen and 30 is a movable platen, each of which is linked to and supported by a press. This press

may be either an electric press or a hydraulic press, and the press is what raises and lowers the movable platen 30 to carry out the required resin sealing.

[0015]

22 is a lower mold base fixed to the fixed platen 20, and 23 is a lower mold fixed to the lower mold base 22. A setting component on which a semiconductor device 16 is placed is provided to the upper surface of the lower mold 23. The semiconductor device 16 used in this method may have a plurality of semiconductor chips 10 equidistantly disposed laterally and longitudinally on a circuit substrate 12. The semiconductor device 16 is placed on the lower mold 23 with the semiconductor chips 10 facing up. 24 is a heater attached to the lower mold base 22. The lower mold 23 is heated by the heater 24, which warms the semiconductor device 16 placed on the lower mold 23. 26 is a lower clamp stopper that restricts the clamping position of the upper and lower molds, and is provided on the lower mold base 22.

[0016]

32 is an upper mold base fixed to the movable platen 30, 33 is an upper mold holder fixed to the upper mold base 32, and 34 is an upper mold fixed to the upper mold holder 33. With this method, the one side of the circuit substrate 12 on which the semiconductor chips 10 are mounted is sealed while flat. Accordingly, the molding surface of the upper mold 34 is formed flat all across the sealing region. 36 is a clamper formed in a shape that surrounds the side surfaces of the upper mold 34 and the upper mold holder 33, and is raisably supported on the upper mold base 32 and always biased toward the lower mold 23 by a spring 37. The molding surface of the upper mold 34 is retracted from the end face of the clamper 36, and during mold closure the sealing region becomes enclosed by the molding surface of the upper mold 34 and the inner surface of the clamper 36. The biasing of the clamper 36 may be accomplished by using a spring 37, an air cylinder, or another such biasing means.

[0017]

38 is a heater attached to the upper mold base 32. This heater 38 heats the upper mold holder 33 and the upper mold 34, and during mold closure heats

the semiconductor device 16. 39 is an upper clamp stopper provided on the upper mold base 32. The upper clamp stopper 39 and the lower clamp stopper 26 are disposed facing each other on the upper and lower mold sides so that their end faces will come into contact during mold closure. When the movable platen 30 is lowered by the press, the position where the upper clamp stopper 39 and the lower clamp stopper 26 come into contact is the mold closure position, and the rubber thickness in the sealing region is restricted by this mold closure position.

[0018]

40a and 40b are tape-like release films formed wide enough to cover the molding surfaces of the upper mold 34 and the lower mold 23. The release films 40a and 40b are provided for the purpose of covering the sealing region so that the silicone rubber composition does not come into direct contact with the molding surface during sealing. The release films 40a and 40b are preferably made from a film material that is flexible and strong enough to be able to conform to the irregularities of the molding surface in the sealing region, that has enough heat resistance to withstand the mold temperature, and that readily releases from the sealing rubber and the mold. Examples of such films include polytetrafluoroethylene resin (PTFE) films, ethylene-tetrafluoroethylene copolymer resin (ETFE) films, tetrafluoroethylene-perfluoropropylene copolymer resin (FEP) films, polyvinylidene fluoride resin (PBDF[1]) films, and other such fluororesin films; and polyethylene terephthalate resin (PET) films and polypropylene resin (PP) films.

[0019]

With this method, when just one side of the circuit substrate 12 is to be sealed, the release film that comes into contact with the silicone rubber is the release film 40a supplied to the upper mold 34. The reason the release film 40b is supplied so as to cover the molding surface of the lower mold 23 is that the compressibility and elasticity of the release film 40b allows any variance in

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[1] Translator's note: Possible typo for "PVDF."

thickness of the circuit substrate 12 to be effectively absorbed, and this allows sealing to be performed without resulting in any burrs or the like. Naturally, it is also possible to supply the release film 40a to just the upper mold 34.

[0020]

42a and 42b are supply rolls of the release films 40a and 40b, and 44a and 44b are take-up rolls for the release films 40a and 40b. As shown in the drawing, the supply rolls 42a and 42b and the take-up rolls 44a and 44b are disposed on either side of the mold, with the supply roll 42a and the take-up roll 44a on the upper mold side being attached to the movable platen 30, and the supply roll 42b and the take-up roll 44b on the lower mold side being attached to the fixed platen 20. Consequently, the release films 40a and 40b conveyed through the inside of the mold from one of the mold to the other. The supply roll 42a and the take-up roll 44a on the upper mold side are raised and lowered along with the movable platen 30. 46 is a guide roller, and 48 is an ionizer for preventing static build-up on the release films 40a and 40b.

[0021]

The release film 40a supplied to the upper mold 34 side is held on the mold surface by air suction. The clamper 36 is provided with air holes 36a formed on the end face of the clamper 36, and air holes 36b formed on the inner surface of the clamper 36. These air holes 36a and 36b communicate with an air mechanism on the outside of the mold. The upper mold holder 33 is provided with an O-ring at the surface that slides against the inner surface of the clamper 36, which prevents air leakage during air suction through the air holes 36b. The space between the inner surface of the clamper 36 and the side surfaces of the upper mold 34 and the upper mold holder 33 serves as an air passage through which air flows. When air suction is applied through the air holes 36b, the release film 40a is held by air suction against the inner surface of the sealing region formed by the upper mold 34 and the clamper 36. The air mechanism that communicates with the air holes 36a and 36b may also provide an air pumping action in addition to its air intake action. Pumping air from the air mechanism to

the air holes 36a and 36b allows the release film 40a to be released more easily from the mold surface.

[0022]

With this method, the configuration described above allows a semiconductor device to be sealed in the following manner. The portion to the left of the center line CL in Fig. 1 depicts the mold in an open state in which the movable platen 30 is in its up position. In this open state, fresh release films 40a and 40b are supplied over the mold surface, and the semiconductor device 16 is placed on the lower mold 23. The semiconductor device 16 is positioned over the release film 40b that covers the molding surface of the lower mold 23.

[0023]

The portion to the right of the center line CL in Fig. 1 depicts a state in which the air mechanism has been actuated and the release film 40a is held by air suction against the end face of the clamper 36 and the upper mold 34. The release film 40a is conveyed close to the mold surface and held against the end face of the clamper 36 by air suction provided through the air holes 36a and 36b, and the release film 40a is also held by air suction along the inner surface of the clamper 36 and the rubber molding surface of the upper mold 34. Because the release film 40a is sufficiently flexible and extensible, it conforms to the irregularities formed by the upper mold 34 and the clamper 36 as it is held by air suction. The air holes 36a provided to the end face of the clamper 36 are disposed with a specific gap between them in the peripheral direction of the upper mold 34.

[0024]

While the release film 40a is held by air suction against the molding surface of the upper mold, a sealing silicone rubber composition 50 is supplied over the circuit substrate 12 of the semiconductor device 16 placed in the lower mold 23. Just enough of the sealing silicone rubber composition 50 is supplied to fill the internal volume of the sealing region, with this supply preferably being accomplished by using a dispenser or the like to discharge a set amount.

[0025]

Fig. 2 illustrates a state in which the semiconductor device 16 is sandwiched between the upper mold 34 and the lower mold 23. The portion to the left of the center line CL in this drawing depicts a state in which the upper mold 34 has been lowered so that the end face of the clamper 36 is pressed against the circuit substrate 12 of the semiconductor device 16. The upper mold 34 does not descend all the way to the clamping position, and filling is commenced while the sealing silicone rubber composition 50 is being pushed on by the upper mold 34 in a state in which the periphery of the sealing region has been blocked off by the clamper 36. The portion to the right of the center line CL in Fig. 2 depicts a state in which the upper mold 34 has descended to the mold closure position. This mold closure position is where the end faces of the upper clamp stopper 39 and the lower clamp stopper 26 come together, and the clamper 36 is moved upward by the mold closing force against the biasing force of the spring 37, until the resin sealing region reaches the specified thickness.

[0026]

When the upper mold 34 descends to the mold closure position, the sealing region is squeezed down to the specified thickness, and the sealing silicone rubber composition 50 completely fills the sealing region. As shown in Fig. 2, a slight gap is formed at the corners of the upper mold 34 and the release film 40a in the portion to the left of the center line CL, but lowering the upper mold 34 to the mold closure position eliminates this gap between the upper mold 34 and the release film 40a, so that the sealing silicone rubber composition 50 does indeed completely fill the sealing region.

[0027]

Interposing the release film 40a at the sealing surface of the semiconductor device 16 allows the periphery around the sealing region to be effectively blocked off by the clamper 36, affording a good seal with no leaks. Even when a circuit pattern is formed on the surface of the circuit substrate 12, so that a slight step is formed on the surface, interposing the release film 40a will allow this stepped portion to be absorbed, preventing the resin from oozing outside of the resin sealing region during mold closure. Also, the release film

40b disposed on the lower side of the circuit substrate 12 absorbs unevenness in the thickness of the semiconductor device through its elasticity in the thickness direction, which affords a good seal.

[0028]

After the mold has been closed and the sealing silicone rubber composition 50 heated and cured, the mold is opened and the semiconductor device that has been sealed with silicone rubber is taken out. Because this sealing is performed via the release films 40a and 40b, the sealing silicone rubber composition 50 does not stick to the molding surface, and since the release films 40a and 40b can be easily removed from the mold, the operations of opening the mold and taking out the semiconductor device are extremely simple. It is also possible to blow air through the air holes 36a and 36b to separate the release film 40a from the mold surface. After he mold is opened, the supply rolls 42a and 42b and the take-up rolls 44a and 44b are actuated and the sealed semiconductor device is conveyed out of the mold along with the release films 40a and 40b.

[0029]

Figs. 3, 4, and 5 show a semiconductor device that has been sealed by this method. Since the upper mold 34 has its molding surface formed flat, the upper surface of the molded portion is also formed flat. As shown, the circuit substrate and silicone rubber can be cut in between adjacent semiconductor chips 10 to obtain individual semiconductor devices. A dicing saw, laser, or the like can be used for this cutting.

[0030]

With this method, as shown in Fig. 6, cavities 34a corresponding to the mounting positions of the various semiconductor chips 10 mounted on the circuit substrate 12 can be provided in the molding surface of the upper mold 34, so that the semiconductor chips 10 are independently resin-sealed in these cavities 34a. Fig. 7 illustrates a semiconductor device sealed with silicone rubber by this method. Again with a semiconductor device such as this, individual semiconductor devices can be obtained by cutting the silicone rubber and the

circuit substrate in between the adjacent semiconductor chips 10. A dicing saw, laser, or the like can be used for this cutting.

[0031]

There are no particular restrictions on the curing mechanism of the sealing silicone rubber composition used in this method, as long as a silicone rubber can be molded by compression molding, but examples [of this composition] include silicone rubber compositions that cure through a hydrosilylation reaction, silicone rubber compositions cured by an organic peroxide, and silicone rubber compositions that cure through a radical reaction. Silicone rubber compositions that cure through a hydrosilylation reaction are particularly favorable because the curing results in no by-products. This silicone rubber composition that cures through a hydrosilylation reaction is composed, for example, of at least (A) an organopolysiloxane having two or more alkenyl groups per molecule, (B) an organohydrogenpolysiloxane having two or more silicon atom-bonded hydrogen atoms per molecule, (C) a platinum-based catalyst, and (D) a filler, and can also contain pigment or a reaction inhibitor as needed. Such silicone rubber compositions are available through standard channels. The sealing silicone rubber composition used in this method can be utilized as a protectant for semiconductor chips or the wiring components thereof, and silicone rubber can also be used as an insulation layer for semiconductor chips or circuit substrates, or as a cushioning layer for semiconductor chips or circuit substrates.

[0032]

This silicone rubber composition is preferably one that, when cured, forms a silicone rubber whose complex elastic modulus is 1 GPa or less. One that forms a silicone rubber whose complex elastic modulus is 100 MPa or less is particularly favorable because the semiconductor chips will be subjected to less stress.

[0033]

Examples of a semiconductor device sealed with silicone rubber by this method include a circuit substrate on which a semiconductor chip will be mounted, a semiconductor chip that has yet to be electrically connected to a

circuit substrate, and a semiconductor wafer that has yet to be cut into individual semiconductor semiconductor [*sic*] devices. As examples of such semiconductor devices, Figs. 3 and 4 illustrate a semiconductor device in which semiconductor chips and their wiring substrate are wire bonded, and a semiconductor device in which semiconductor chips [having] a plurality of lead wires and their wiring substrate are wire bonded.[2] With the semiconductor device shown in Fig. 3, the semiconductor chips 10 are mounted with a die-bonding agent on a circuit substrate 12 made from a polyimide resin, epoxy resin, BT resin, or ceramic, after which they are wire bonded on the circuit substrate 12 by bonding wires 11 composed of gold or aluminum. With the semiconductor device shown in Fig. 4, the semiconductor chips 10 are electrically connected to the circuit substrate 12 by solder balls or conductive bumps. With this semiconductor device, an underfill agent is injected for the purpose of reinforcing the solder balls or conductive bumps. A curable epoxy resin composition or curable silicone composition is used as this underfill agent. With the semiconductor devices shown in Figs. 3 and 4, after sealing with a silicone rubber, external electrodes such as solder balls 5 are formed on the bottom surface of the circuit substrate 12 on which the semiconductor chips 10 are mounted, in order to join this semiconductor device to another circuit substrate. When a plurality of semiconductor chips are sealed at the same time on a circuit substrate, they are cut into individual semiconductor devices by sawing or punching. Fig. 5 illustrates a wafer-level CSP.

[0034]

In this method, if the silicone rubber composition comes into direct contact with the mold surface when the above-mentioned compression molding machine is used to seal a semiconductor device with silicone rubber, since substances with a slimy feel will stick to a mold surface, it is preferable for a release film to be interposed as above in the compression molding. Using a release film makes

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[2] Translator's note: There may be an error in the Japanese here. Please check the "fukusuu no riido sen ga" part.

continuous resin sealing possible, and allows the interval between cleaning, etc., of the mold to be extended, which improves production efficiency.

[0035]

There are no particular restrictions on the compression molding conditions in this method, but keeping the heating temperature between 60 and 150°C is preferable because this reduces the stress to which the circuit substrate and the semiconductor chips are subjected. Also, preheating the mold enhances the cycle time of the compression molding. Furthermore, placing drops of silicone rubber composition onto a preheated[3] circuit substrate allows the spreading of the silicone rubber composition to be controlled better, although this does depend on the type of silicone rubber composition being used.

[0036]

The semiconductor device of the present invention will now be described. The semiconductor device of the present invention is characterized by being manufactured by the method discussed above. Since a semiconductor device such as this contains no voids in the sealing rubber, the resulting appearance is better and there is no decrease in moisture resistance. Also, the thickness of the sealing rubber can be precisely controlled in the semiconductor device of the present invention, which helps make electronic devices thinner and more compact. Also, there is no disconnection or contact of the bonding wires in the semiconductor device of the present invention, and there is less warping of the semiconductor chips or circuit substrate, so reliability is superior, which means that this device can be used in a wider range of fields.

[0037]

Examples

The method for manufacturing a semiconductor device, and the semiconductor device thus obtained, of the present invention will now be

[3] Translator's note: There is apparently a typo in the Japanese word for preheat here.

described through examples and comparative examples. The semiconductor device was evaluated as follows.

Appearance and fillability: The surface of a semiconductor device that had been sealed with silicone rubber or cured epoxy resin was observed visually, and was rated good if the entire surface was smooth, fair if part of the surface was not smooth, and poor if none of the surface was smooth.

Warping: The long side of a circuit substrate that had been sealed with silicone rubber or a cured epoxy resin, prior to being cut into individual semiconductor devices, was fixed, and the height of the other long side at this point was measured and expressed as the warpage.

[0038]

A silicone rubber composition A (TX-2287-2 made by Dow Corning Toray Silicone) and a silicone rubber composition B (TX-2287-4 made by Dow Corning Toray Silicone) having the characteristics shown in Table 1 were used as the hydrosilylation reaction-curing silicone rubber composition in the examples. The viscosity of the silicone rubber composition was measured at 25°C using a BS rotary viscometer (Viscometer Model BS made by Tokimec; rotor: No. 7, speed: 10 rpm). A silicone rubber was produced by compression molding the silicone rubber composition for 3 minutes at 140°C and under a load of 30 kgf/cm$^2$, then performing a heat treatment for 1 hour in a 150°C oven. The complex elastic modulus of this silicone rubber was measured at 25°C using a viscoelasticity measurement device (shear frequency: 1 Hz, modulus of strain: 0.5%) The thermal swelling of this silicone rubber was measured at a temperature between 50 and 150°C using a thermal mechanical analyzer (TMA).

[0039]

Table 1

| Silicone rubber composition | | A | B |
|---|---|---|---|
| Before curing | Appearance | black, pasty | black, pasty |
| | Viscosity (Pa · s) | 280 | 150 |
| After curing | Appearance | black, rubbery | black, rubbery |
| | Hardness (type A durometer) | 70 | 90 |
| | Complex elastic modulus (MPa) | 4 | 20 |
| | Thermal swelling (ppp/°C) | 170 | 170 |

[0040]

Example 1

The semiconductor device shown in Fig. 3 was produced. Specifically, semiconductor chips 3[4] measuring 8 × 14 mm were joined via a die-bonding layer 2 made from an epoxy resin and having a thickness of 35 $\mu$m to a circuit substrate 1 made from a polyimide resin and measuring 70 × 160 mm (a copper foil 18 $\mu$m in thickness was laminated to one side of a polyimide resin film with a thickness of 75 $\mu$m via an epoxy resin adhesive layer with a thickness of 17 $\mu$m, a circuit pattern was formed from this copper foil, the portion of this circuit pattern used for wire bonding was removed, and the surface of the circuit substrate was covered with a photosensitive solder mask). Next, wiring bonding was performed with 48 metal bonding wires 4 used for electrically connecting the bumps (not shown) of these semiconductor chips 3 to the circuit pattern. A total of 54 semiconductor chips were mounted on this circuit substrate in three blocks of 18 chips, and wire bonding was performed for each circuit.

[0041]

Specific locations on the polyimide resin circuit substrate 1 on which these semiconductor chips 3 had been mounted were coated at room temperature with

[4] Translator's note: The numbers such as 1, 2, and 3 do not seem to appear in any of the drawings.

a total of 20 g of the hydrosilylation reaction-curing silicone rubber composition A, after which this circuit substrate was placed in the lower mold of the compression molding machine shown in Fig. 1. Next, the upper and lower molds of this compression molding machine (a release film made from polytetrafluoroethylene resin was held by air suction against the inside of the upper mold in order to prevent mold fouling and to improve release of the silicone rubber) were put together so as to sandwich the circuit substrate, and compression molding was performed for 3 minutes at 140°C and under a load of 30 $kgf/cm^2$. The resin-sealed semiconductor device was then taken out of the mold and heat treated for 1 hour in a 150°C oven. This semiconductor device had been sealed with silicone rubber in a thickness of 400 $\mu$m on the surface of the semiconductor chips, the surface of this silicone rubber was smooth and free of voids, and both the appearance and fillability were rated good. The warping of the circuit substrate was 0.05 mm.

[0042]

Example 2

The semiconductor device shown in Fig. 4 was produced. Specifically, the bump connection portion (not shown) of a glass fiber-reinforced epoxy resin circuit substrate 6 measuring 45 × 175 mm (a copper foil 18 $\mu$m in thickness was laminated to one side of a glass fiber-reinforced epoxy resin film with a thickness of 90 $\mu$m via an epoxy resin adhesive layer with a thickness of 18 $\mu$m, a circuit pattern was formed from this copper foil, the portion of this circuit pattern used for wire bonding was removed, and the surface of the circuit substrate was covered with a photosensitive solder mask) was printed with solder paste, then the bonding pad portions of semiconductor chips 3 (6 × 6 mm) were aligned with these solder paste portions, and everything was placed in a reflow furnace, where the solder was heated and melted and the semiconductor chips were electrically connected to the circuit pattern by the solder bumps 7. Next, an epoxy resin underfill agent 8 was injected at room temperature between the semiconductor chips 3 and the circuit substrate, after which heating was

performed in stages, with the final stage involving heating for 3 hours at 180°C, which cured this underfill agent. 108 semiconductor chips were mounted on the circuit substrate in three blocks of 36 chips. The diameter of the solder bumps was 300 $\mu$m, and the number of bumps was 112 per semiconductor chip.

[0043]

Specific locations on the glass fiber-reinforced epoxy resin circuit substrate 6 on which these semiconductor chips 3 had been mounted were coated at room temperature with a total of 10 g of the hydrosilylation reaction-curing silicone rubber composition A, after which this circuit substrate was placed in the lower mold of the compression molding machine shown in Fig. 1. Next, the upper and lower molds of this compression molding machine (a release film made from polytetrafluoroethylene resin was held by air suction against the inside of the upper mold in order to prevent mold fouling and to improve release of the silicone rubber) were put together so as to sandwich the circuit substrate, and compression molding was performed for 2 minutes at 120°C and under a load of 30 kgf/cm$^2$. The resin-sealed semiconductor device was then taken out of the mold and heat treated for 1 hour in a 150°C oven. This semiconductor device had been sealed with silicone rubber in a thickness of 230 $\mu$m on the surface of the semiconductor chips, the surface of this silicone rubber was smooth and free of voids, and both the appearance and fillability were rated good. The warping of the circuit substrate was 0.05 mm.

[0044]

Example 3

The semiconductor device shown in Fig. 5 was produced. Specifically, in a wafer-level CSP with a diameter of 8 inches and a thickness of 300 $\mu$m, a re-wiring layer (not shown) and a buffer layer (not shown) were formed on this wafer surface, after which solder balls 12 were formed for connecting to external circuits. This wafer surface was coated at room temperature with 2 g of the hydrosilylation reaction-curing silicone rubber composition B, after which the wafer was placed in the lower mold of the compression molding machine shown

in Fig. 1. Next, the upper and lower molds of this compression molding machine (a release film made from polytetrafluoroethylene resin was held by air suction against the inside of the upper mold in order to prevent mold fouling and to improve release of the silicone rubber) were put together so as to sandwich the wafer, and compression molding was performed in this state for 2 minutes at 120°C and under a load of 30 kgf/cm$^2$. The resin-sealed wafer was then taken out of the mold and heat treated for 1 hour in a 150°C oven. This semiconductor device[5] had been sealed with silicone rubber in a thickness of 400 $\mu$m on the wafer surface, the surface of this silicone rubber was smooth and free of voids, and both the appearance and fillability were rated good. The warping of the circuit substrate was 0.2 mm.

[0045]

Comparative Example 1

A semiconductor device was produced in the same manner as in Example 1, except that a liquid curable epoxy resin composition having the characteristics shown in Table 2 (CEL-C-7400 made by Hitachi Chemical) was used instead of the hydrosilylation reaction-curing silicone rubber composition A used in Example 1. The molding conditions involved performing compression molding for 5 minutes at 170°C and under a load of 30 kgf/cm$^2$, followed by heat treatment for 1 hour in a 150°C oven. This semiconductor device had been sealed with a cured epoxy resin in a thickness of 230 $\mu$m on the surface of the semiconductor chips, the surface of this sealing epoxy resin was smooth and free of voids, and both the appearance and fillability were rated good. The warping of the circuit substrate was 7 mm.

[0046]

Table 2

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[5] Translator's note: Error for "wafer?"

| | | Liquid curable epoxy resin composition |
|---|---|---|
| Before curing | Appearance | black, pasty |
| | Viscosity (Pa · s) | 30 |
| After curing | Appearance | black |
| | Hardness (type A durometer) | > 90 |
| | Complex elastic modulus (MPa) | 7 |
| | Thermal swelling (ppp/°C) | 6 (room temperature to 90°C) |

[0047]

The viscosity of the curable epoxy resin composition was measured at 25°C using a BS rotary viscometer (Viscometer Model BS made by Tokimec; rotor: No. 7, speed: 10 rpm). A cured epoxy resin was produced by compression molding the curable epoxy resin composition for 5 minutes at 170°C and under a load of 30 kgf/cm$^2$, then performing a heat treatment for 1 hour in a 150°C oven. The complex elastic modulus of this cured epoxy resin was measured at 25°C using a viscoelasticity measurement device (shear frequency: 1 Hz, modulus of strain: 0.5%) The thermal swelling of this cured epoxy resin was measured at a temperature between 50 and 150°C using a thermal mechanical analyzer (TMA).

[0048]

Comparative Example 2

A semiconductor device was produced in the same manner as in Example 3, except that a liquid curable epoxy resin composition having the characteristics shown in Table 2 was used instead of the hydrosilylation reaction-curing silicone rubber composition A used in Example 3. The molding conditions involved performing compression molding for 5 minutes at 170°C and under a load of 30 kgf/cm$^2$, followed by heat treatment for 1 hour in a 150°C oven. This semiconductor device had been sealed with a cured epoxy resin in a thickness of

400 $\mu$m on the wafer surface, the surface of this sealing epoxy resin was smooth and free of voids, and both the appearance and fillability were rated good. The warping of the circuit substrate, however, was 6 mm.

[0049]

Effect of the Invention

With the method of the present invention for manufacturing a semiconductor device, in the sealing of a semiconductor device, no voids develop, the thickness of the sealing rubber can be controlled precisely, there is no disconnection or contact of the bonding wire, and there is less warping of the semiconductor chip or circuit substrate. The semiconductor device of the present invention has the advantages mentioned above.

Brief Description of the Drawings

Fig. 1 is a diagram illustrating the structure of the compression molding machine used in the method of the present invention for manufacturing a semiconductor device;

Fig. 2 is a diagram illustrating how a semiconductor device is resin-sealed with the compression molding machine used in the method of the present invention for manufacturing a semiconductor device;

Fig. 3 is a cross section of the semiconductor device in Example 1 of the present invention;

Fig. 4 is a cross section of the semiconductor device in Example 2 of the present invention;

Fig. 5 is a cross section of the semiconductor device in Example 3 of the present invention;

Fig. 6 is a diagram illustrating the structure of the compression molding machine used in the method of the present invention for manufacturing a semiconductor device; and

Fig. 7 is an oblique view of the semiconductor device in an example of the present invention.

Key:

10 semiconductor chip

12 circuit substrate

16 semiconductor device

20 fixed platen

22 lower mold base

23 lower mold

24 heater

26 lower clamp stopper

30 movable platen

32 upper mold base

33 upper mold holder

34 upper mold

34a cavity

36 clamper

36a, 36b air holes

37 spring

38 heater

39 upper clamp stopper

40a, 40b release films

42a, 42b supply rolls

44a, 44b take-up rolls

46 guide roller

48 ionizer

50 sealing silicone rubber composition

70 semiconductor device sealed with sealing rubber

72 sealing rubber

Document Title: Abstract


Abstract

Object: To provide a method for manufacturing a semiconductor device, with which no voids develop in the sealing of the semiconductor device, the thickness of the sealing rubber can be controlled precisely, there is no disconnection or contact of the bonding wire, and there is less warping of the semiconductor chip or circuit substrate, and to provide a semiconductor device having these advantages.

Means for Solution: A method for manufacturing a semiconductor device sealed with silicone rubber, characterized in that a semiconductor device is placed in a mold, and a sealing silicone rubber composition is supplied between the mold and the semiconductor device and compression molded.

Selected Figure: Fig. 1

Document Title: Drawings

Fig. 1

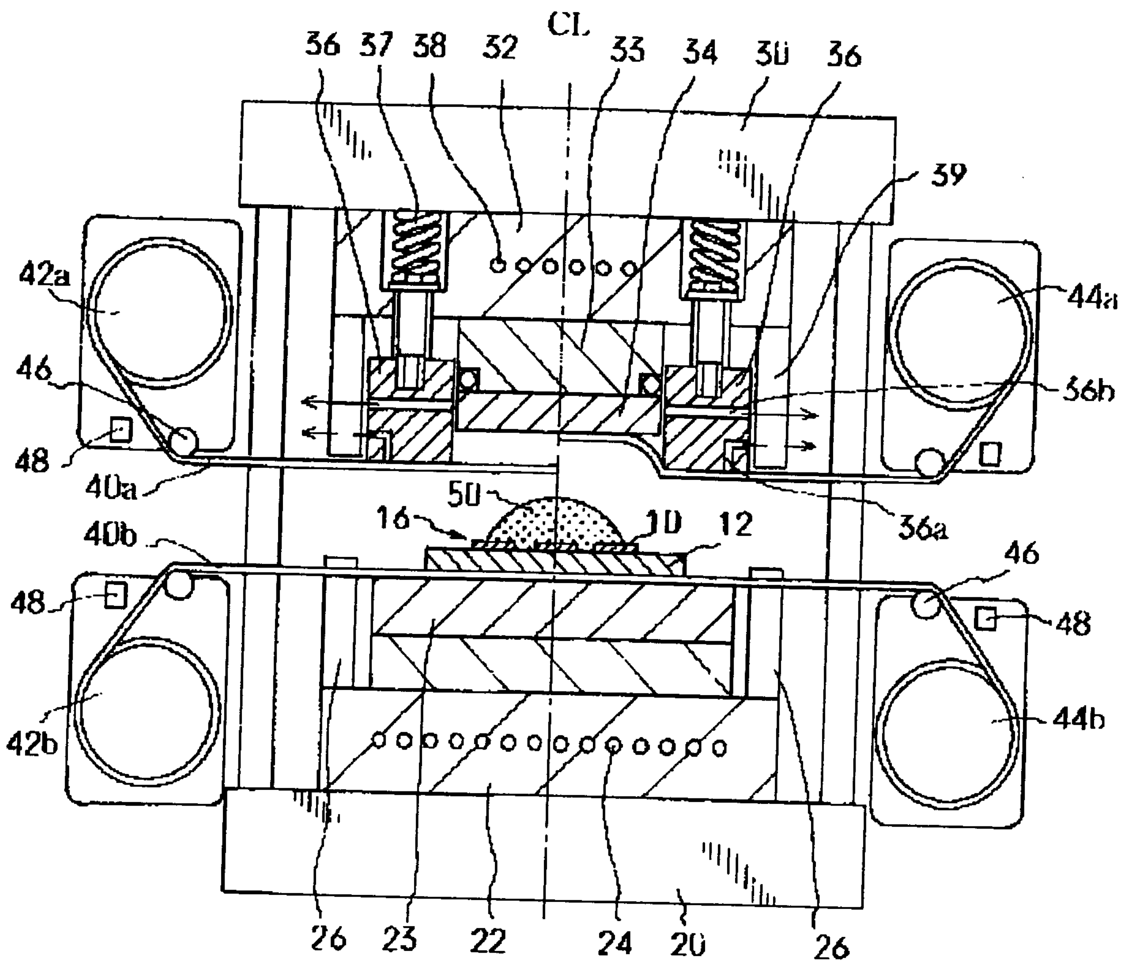

Fig. 2

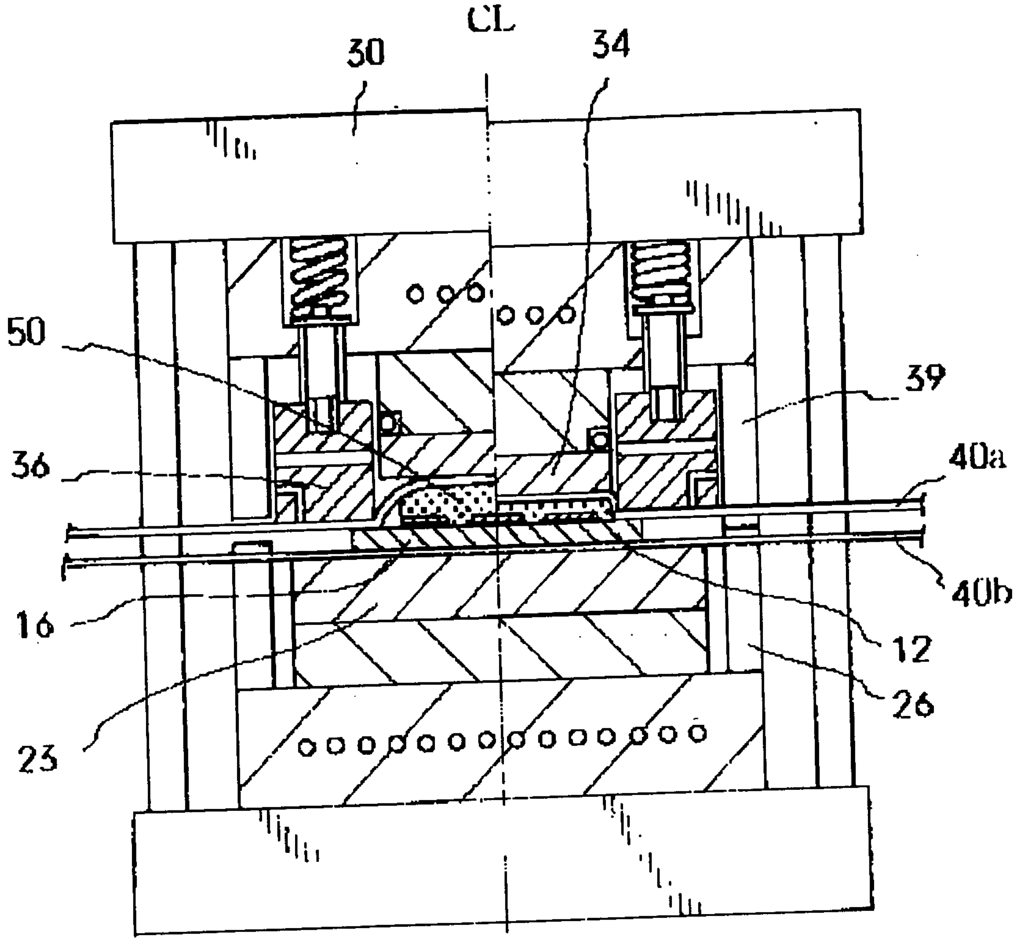


Fig. 3

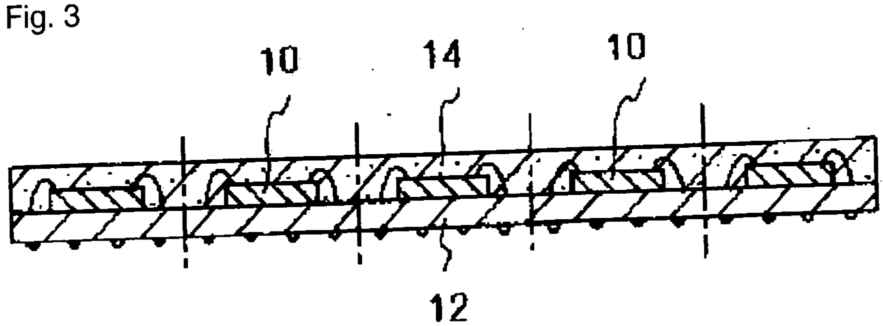

Fig. 4

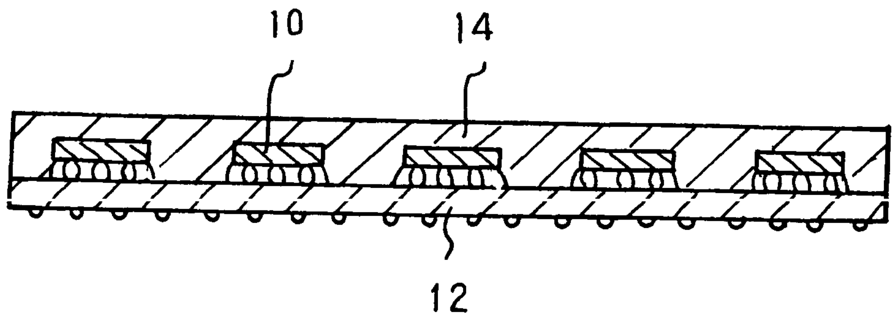


Fig. 5

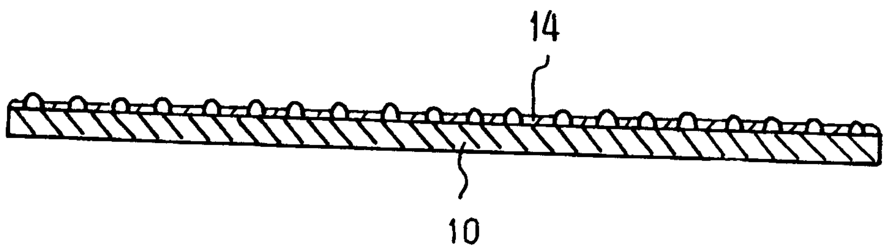

Fig. 6

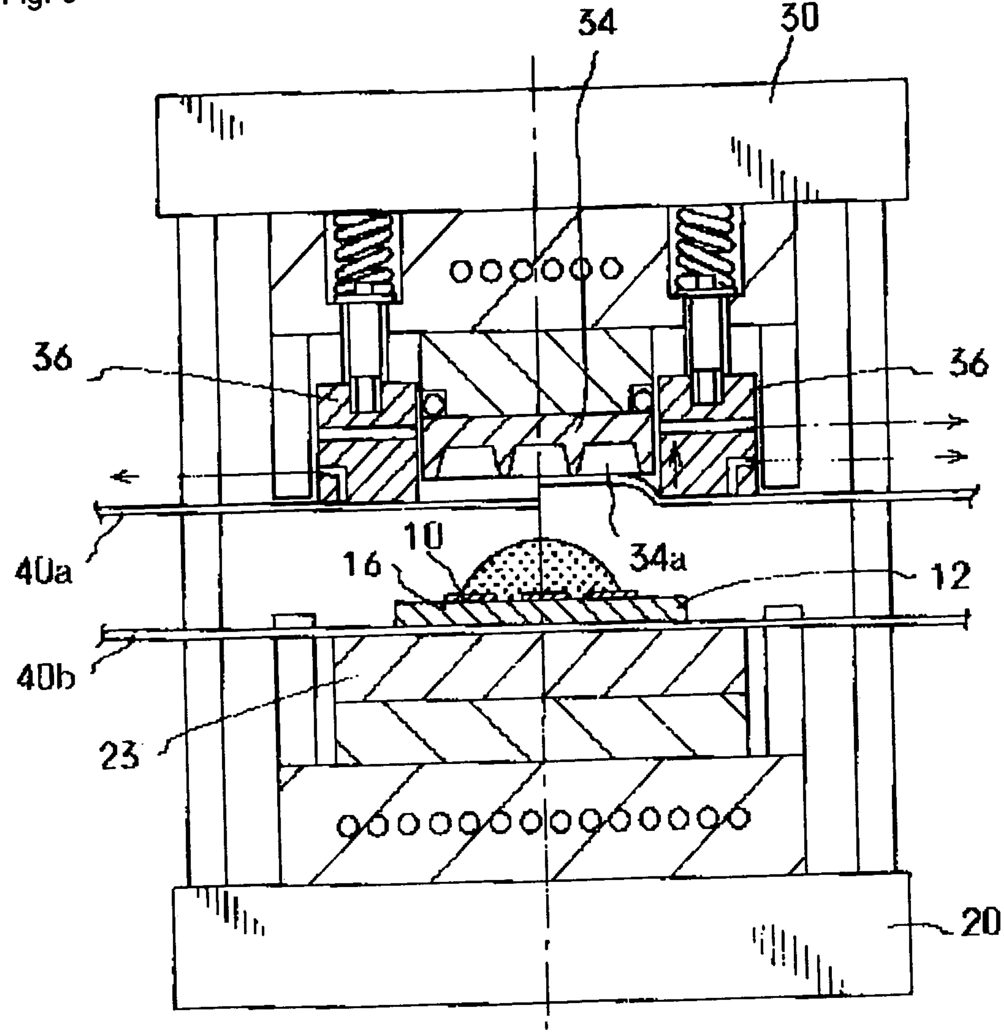

Fig. 7